TRANSFER OF REINFORCING FUNCTION ACROSS MEMBERS OF EQUIVALENCE CLASSES

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1987

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Abstract of Dissertation Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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December 1987

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Recent research on the transfer of discriminative control across elements of equivalence classes suggests that other stimulus functions may transfer as well. In this study, nonreinforcing consequences were identified for six subjects. For each subject, the nonreinforcing stimulus was made a member of a three element equivalence class using matching-to-sample training. The other two members of the class were functional reinforcers individually identified for each subject. Thus, an equivalence class of individually assessed stimuli was made for each subject consisting of two identified reinforcers and one nonreinforcing stimulus. Following formation of the equivalence class, testing was conducted to determine if the previously nonreinforcing stimulus had acquired a reinforcing function. The data showed that transfer of reinforcing function across members of the equivalence class was obtained for four of the six subjects.

INTRODUCTION

Interest in the study of stimulus control has for many years focused on the study of stimulus gradients based on physical properties. Stimulus classes based on common properties are important because they enable us to respond appropriately to novel stimuli sharing properties with previously encountered stimuli. For example, children who have learned to identify correctly certain examples of the stimulus class "book" may recognize some novel examples as members of the class.

While common physical properties are useful for identifying members of certain stimulus classes, in other cases they are not adequate for classifying stimuli. That is, in some stimulus classes the members have no common physical properties that distinguish them from members of other classes. For example, while there are common physical properties that enable us to recognize two individuals as members of the class "adult male," there are no distinguishing physical features that allow one to identify males as members of the class "college professor" or "football coach."

Stimulus classes lacking common physical properties are important because they permit flexible adaptation to the

environment. To use an imaginary example, suppose that in our prehistory that our ancestors classed together such diverse creatures as caribou, squirrel, and mallards (in a Neanderthalic equivalent of "edible"). The discovery that prolonged contact with heat dramatically changed the flavor and texture of caribou meat may have quickly led to the application of this new technology to the other class members without laborious trial and error learning. This kind of generalization allows behavior to adapt efficiently and flexibly to the environment and has probably contributed to our position in the natural order.

Thus, these classes are particularly important because when an individual learns to make the same response to two physically dissimilar stimuli and then learns to make a new response to only one of those stimuli, it is likely that the new response will be made to the remaining stimulus without additional training (Spradlin, 1982).

A recent experimental demonstration of the utility of such stimulus classes was published by Silverman and his colleagues (Silverman, Anderson, Marshall, & Baer, 1986). In this study four puppets were divided into two pairs, each containing one human-like and one animal-like puppet. Thus, each puppet was physically more similar to a puppet in the other pair than to the puppet in its own pair. Child subjects were taught to match each puppet of each pair to the other puppet of its pair. That is, the four puppets were presented simultaneously, then the experimenter moved

one of the puppets toward the subject and asked, "Who goes with this one?" Correct responses were followed by praise and a token; incorrect responses were corrected. Following five consecutive correct responses, the procedure was changed to a conventional match-to-sample procedure. During matching-to-sample teaching the sample puppet, presented alone, asked the subject "Who goes with me?" The two comparison puppets were then presented. Touching the comparison puppet from the sample puppet's pair was reinforced. The delay between removal of the sample puppet and presentation of the comparison puppets was increased gradually to two minutes.

Next subjects were taught to label each member of the puppet pairs. For example, two of puppets were called "Zoot," and the other two were called "Theta."

Finally, subjects were taught to make auditory-visual matches. On each trial two puppets, one from each pair, were presented, and the experimenter said "Point to [name]." Touching the named puppet was reinforced.

This training established the puppets of one pair as members of one stimulus class and puppets of the other pair as members of a different class. In each class, one puppet was designated as the teacher puppet; the other was designated the prober puppet. The teacher puppet taught the subjects answers to questions about opposites. Each teacher taught a particular repertoire of responses. For example, teacher A taught the response "skinny" to the question "What

is the opposite of fat?" while teacher B taught the response "thin" to the same question. After this training was mastered, the prober puppet was introduced to assess the degree to which responding would transfer. All of the subjects emitted the responses from the appropriate repertoire. That is, when in the presence of prober A, the responses taught by teacher A were emitted, and in the presence of prober B, the responses taught by teacher B were emitted. These results demonstrated that it is possible to establish classes such that if one member of the class controls a particular verbal repertoire through direct teaching, another member of the stimulus class will control the same repertoire without direct teaching. Thus, as a result of stimulus classes, responding may occur in the presence of stimuli in whose presence reinforcement has never occurred.

More recently, interest has focused on a special subset of stimulus classes known as equivalence classes, which have been recognized as important in the study of how new environments direct and maintain behavior (Sidman, 1986; Spradlin, 1977). Because the elements of these classes are functionally substitutable as discriminative stimuli, it seems reasonable to ask whether any function acquired by one member of an equivalence class may transfer to the other members of the class. Before discussing this question further, a general description of stimulus equivalence will be presented.

Stimulus Equivalence

Sidman, Cresson, and Willson-Morris (1974) showed that after a series of conditional discriminations has been learned, the component stimuli may become related to each other in novel ways that were not explicitly trained. That is, if a subject is taught to select B in the presence of A, and also taught to select C in the presence of A, he or she may also select A in the presence of B, and select A in the presence of C, without additional training. Even more importantly, the subject may now be able to select B in the presence of C and to select C in the presence of B, without explicit instruction in this task. For example, if a child is taught to match the spoken word "square" to a picture of a square and then taught to match the printed word SQUARE to a picture of a square, upon testing it is likely that the child will be able to match the picture of the square to the printed word SQUARE, as well as to match the spoken word "square" to the printed word SQUARE, despite the fact that these relations were never directly trained (see Figure 1).

According to Sidman and Tailby (1982) three features define an equivalence class: reflexivity, symmetry, and transitivity. To demonstrate that the relation between two stimuli is reflexive, subjects must match identical stimuli without direct training. That is, when presented with stimulus A, A must be selected from an array of alternatives

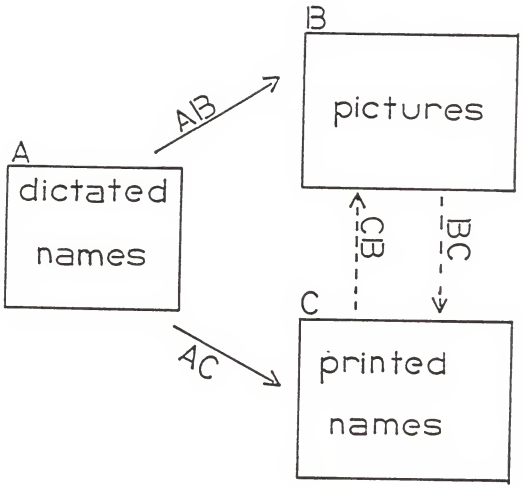

Figure 1. The stimulus equivalence paradigm.

under conditions of non-reinforcement. In other words, the proof of reflexivity is generalized identity matching (Sidman & Tailby, 1982).

To demonstrate that the relation is symmetric, a conditional relation must be shown to be functionally reversible. After being taught to match a specific sample stimulus with a specific comparison stimulus, the subject must then be able to match the two stimuli when the sample and comparison roles are reversed. That is, a subject who is trained to match sample A to comparison B must then match sample B to comparison A without explicit training and in the absence of programmed reinforcement. This functional sample-comparison reversibility is taken as evidence of symmetrical responding (Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrington, 1982).

Demonstration that a conditional relation is transitive requires a minimum of three stimuli. The subject must respond in the same manner to two stimuli that have never been directly related to one another following training in which each of the two stimuli has been related to a common third stimulus. For example, if, following the establishment of the conditional discriminations "if A, then B" and "if B, then C" the relation "if A, then C" emerges without additional training, transitivity has been demonstrated (Sidman & Tailby, 1982).

Performances of this kind have been observed in a variety of subjects, including handicapped as well as normal children and adults (e.g., Lazar, 1977; Sidman & Tailby, 1982; Devany et al., 1986; Sidman et al., 1974; Spradlin, Cotter, & Baxley, 1973; Spradlin & Dixon, 1976). Equivalence classes have been formed using visual stimuli (e.g., Wetherby, Karlan, & Spradlin, 1983; Lazar et al., 1984), as well as both visual and auditory stimuli (e.g., Sidman & Cresson, 1973; Dixon, 1978; Dixon & Spradlin, 1976). These stimulus classes are nearly ubiquitous in humans and are easily formed with auditory and visual stimuli. There is widespread agreement that stimulus equivalence is important to our ability to analyze language successfully (e.g., Spradlin, 1977; Devany et al., 1986). Some even argue that the equivalence phenomenon is the foundation or basis for reference or semantics (e.g., Sidman, 1986).

Equivalence classes may be important in other ways as well. For example, suppose that an equivalence class is composed of stimuli A, B, C and that element A is given a new discriminative function. It might be expected that elements B and C would also acquire the discriminative function without additional training as a function of their participation in an equivalence class with element A. This is essentially what was obtained in the study by Silverman et al. (1976) described previously.

Transfer of Discriminative Control

Few other studies investigating the transfer of discriminative control and equivalence classes have been published. In one (Lazar, 1977), three adult subjects were taught to perform several different ordering tasks, that is, to touch first one item and then another in a visual array. Two classes were created as a result of this training: the "firsts" and the "seconds." In a subsequent matching-to-sample task, a stimulus (either a "first" or a "second") now served as a sample, and novel visual stimuli served as comparisons. Responses to some comparison stimuli were reinforced when the sample was a "first" stimulus, and responses to other stimuli were reinforced when the sample was a member of the "second" class. Following this phase, the ordering task was again presented, using the comparison stimuli from the matching-to-sample task. The results indicated that two out of three subjects pointed to these stimuli in the order predicted on the basis of the stimulus class membership of the comparisons. That is, they first pointed to stimuli that had been matched with "firsts" and then pointed to stimuli that had been matched with "seconds."

An investigation by Wulfert and Hayes (1987) also demonstrated the transfer of discriminative control. In this study eight adults were taught conditional discriminations using modified Greek letters. The

matching-to-sample training led to the formation of two four-member equivalence classes (A1, B1, C1, D1 and A2, B2, C2, D2). The subjects were then taught to pick one comparison stimulus from each class in a set order. For example, the B1 and B2 stimuli were presented and subjects were required to touch first B1 and then B2. The position was varied across trials. If subjects touched the stimuli in the correct sequence, the word "correct" and the number of points earned were displayed. If the stimuli were touched in the incorrect sequence, the word "wrong" appeared. Following this training, subjects were able to order correctly the other untrained stimulus pairs (A1-A2, C1-C2, D1-D2). After subjects met criterion on this task, the 1's and 2's were presented in random combinations (e.g., A1-C2, D1-B2) to determine if the functions "first" and "second" were bound to specific stimulus pairings. All subjects showed the transfer of the sequence response through equivalence classes.

The ordering response was then brought under conditional control. In the presence of Tone 1, responding first to B1, and then to B2 was reinforced, while in the presence of Tone 2, responding first to B2, and then to B1 was reinforced. Following criterion performance on this task, a random sequence test was conducted, similar to that described above. The results of this study showed that both ordering and conditional ordering responses transferred to all of the other members of the two equivalence classes.

In another study (Hayes, Brownstein, Devany, Kohlenberg, & Shelby, in press), college students were taught a series of conditional discriminations using nonsense syllables. This resulted in the formation of two equivalence classes (called ABC and DEF). One stimulus from each equivalence class then was given a discriminative function. Subjects were told only that they would be shown some nonsense syllables and that "one meant to clap while the other meant to wave." The B and E syllables were then presented in random order. In the presence of the B syllable, clapping was followed by the statement "correct." In the presence of the E syllable, waving was followed by "correct." Incorrect responses were ignored.

After the subjects' performance met criterion, they were tested to determine whether discriminative control had transferred to untrained members of the equivalence classes. On half the test trials syllable C was presented; on the remaining half syllable F was presented. The subject's response (clap, wave, or no response) was recorded for each trial. If transfer of control had occurred, syllable C would occasion clapping and syllable F waving. The results indicated that such responding did occur, thus demonstrating the transfer of discriminative control.

In summary, the currently available evidence suggests that discriminative functions acquired by one element of an equivalence class will transfer to the other elements in the class without additional training or exposure. The

successful transfer of discriminative control raises the question of whether other stimulus functions will transfer across members of an equivalence class as well.

Transfer of Reinforcing Function

A recent study by Dube, McIlvane, Mackay, and Stoddard (1987) investigated the possibility that reinforcers may become members of equivalence classes. In this study, two foods of approximately equal preference were identified for each of two retarded subjects. Two sets of stimuli were generated, each consisting of a spoken name, an object, and an arbitrary visual stimulus. Subjects were taught to match the arbitrary visual stimuli to spoken names and to match objects with the arbitrary visual stimuli. All responses involving stimuli from set one were consequated with praise and the delivery of a specific food. All responses involving stimuli from set two were consequated with praise and the delivery of a different specific food. Subsequent testing indicated that two equivalence classes formed. Each consisted of the arbitrary visual stimulus, spoken name, and object associated during the conditional discrimination training. In addition, the specific food consequence used in the conditional discrimination training was also found to be a member of the equivalence class.

This study is important because it provides evidence that reinforcers themselves may become members of equivalence classes. Class membership, in other words, may not be confined to elements used in the matching-to-sample training task. As we know that discriminative functions may transfer to other class members, it seems reasonable to speculate that other class members may acquire a reinforcing function if reinforcers participate in the class. Dube et al. did not determine whether any transfer of reinforcing function occurred. In fact, very few data have been collected on this question, and those data are unclear.

The only data available were collected by Hayes et al. (in press) as part of the study described earlier. Three additional adult subjects were instructed to sort unfamiliar nonsense syllables into two bins. For each syllable, placement in the right or left bin had arbitrarily been designated as correct. For example, QOD-left or PIZ-right might be correct. Correct responses resulted in the presentation of the B stimulus from the ABC equivalence, class followed by the word "good." Incorrect responses resulted in the presentation of the E stimulus, followed by the word "no."

After a subject's performance met criterion on this sorting task, a new sorting task was introduced. Correct responses during this second sorting task were followed only by the presentation of the B stimulus; incorrect responses

were followed by presentation of the E stimulus. This continued until 20 consecutive correct responses had been made. The entire training sequence was then repeated.

Following criterion performance on the final task, subjects were tested to see if the reinforcing function of the B stimulus had transferred to untrained members of the equivalence class. This test consisted of another sorting task of the same type used earlier: sorting unfamiliar nonsense syllables into two bins, with the "correct" bin for each syllable arbitrarily selected. Correct responses were followed by the presentation of the C stimulus; incorrect responses were followed by presentation of the F stimulus. The experimenter did not speak.

Two of the three subjects demonstrated 100 percent correct responding on the test. These results provide some support for the notion that when one member of an equivalence class acquires a reinforcing function, other members will acquire the function without explicit pairing. However, this study suffered from a number of problems. For example, no effort was made to control for experimental "demand" effects (Orne, 1962). In addition, the two subjects who clearly showed the effect responded in the same way throughout the test, with no variability in responding. Given this observation, it is possible that subjects perseverated on the first response they made and that the response-specific contingencies had little effect.

Nevertheless, these data encourage speculation that previously neutral stimuli may come to function as reinforcers through participation in equivalence classes.

As noted earlier, if the members of an equivalence class are functionally substitutable, then it seems reasonable to expect that if some members share a common function, the other members of the class will also acquire these functional properties. The existing data tend to support this notion. There is clear evidence that this phenomenon will occur with discriminative functions, and there is some suggestion that it will occur with reinforcing functions. It also seems reasonable to suppose that this transfer would occur even if the function was not acquired following the formation of the equivalence class, but existed prior to its formation. For example, suppose that stimulus A was a member of the class "X." If stimulus B were then made equivalent to stimulus A, B might also be expected to become a member of the class of "X" (Lazar, 1977). Stimulus A may be a member of a class of stimuli defined by their reinforcing function ("current reinforcers"). If stimulus B were then made equivalent to stimulus A through matching-to-sample training, it seems reasonable to expect that B would also become a member of the class "current reinforcer."

The present study is designed to determine whether a nonreinforcing stimulus that is made a member of an equivalence class with existing reinforcers will itself

acquire a reinforcing function. The hypothesis that reinforcing function will transfer as a result of participation in an equivalence class would be supported if a previously nonreinforcing stimulus can be shown to increase in reinforcing effectiveness.

METHOD

Subjects and Setting

Six individuals served as subjects for this experiment. Three of the subjects were preschool children enrolled at a day care center for economically disadvantaged children. (A fourth preschool child's participation was terminated when she failed to meet mastery criterion on any visual discrimination task after 44 experimental sessions.) The three children (Brian, Damien, and Gloria, names changed to protect confidentiality) were all 4-years-old at the time of the study. Two subjects (Dorothy and Claudia) were undergraduate college students enrolled in an introductory psychology class. One subject (Sadie) was an 8-year-old girl enrolled in a local elementary school.

The sessions for the preschool children were conducted in a vacant classroom at the preschool where subjects were enrolled. The sessions for the remaining three subjects were conducted in a small university office. During all sessions the subject and experimenter were seated at a table facing each other. Experimental materials were placed on the table in front of the subject. The number of sessions varied for each child subject (range 10 to 50). Each session lasted 20 to 30 minutes for the four children. Each

of the two adult subjects participated in two 90 minute sessions. The number of sessions for each subject by condition is presented in Table 1.

Stimuli

Visual discrimination tasks. Visual discrimination tasks were used in order to permit the identification of reinforcing and nonreinforcing stimuli and to assess the transfer of reinforcing function. Stimuli consisted of figures approximately one inch tall drawn in black ink and centered on a white three by five index card. The particular discrimination tasks varied for each subject. Tasks were selected that were appropriate for each subject and that had not been previously mastered. For example, for the preschool subjects, the tasks included pre-academic skills such as letter discrimination. For college students, the stimuli were Chinese characters (taken from Hull, 1920). Regardless of the particular stimuli used, tasks were selected that were judged to be of relatively equal difficulty. The stimuli for each subject are presented in Table 2.

Conditional discrimination training. For each subject, two of the stimuli used in conditional discrimination training had been previously identified as reinforcers during Phase 1 of the experiment. A third stimulus used in conditional discrimination training was a nonreinforcing

Table 1. Number of sessions per subject by condition.

SUBJECT	CONDITION	NUMBER OF SESSIONS
Damien	Assessment of reinforcing and nonreinforcing stimuli	23
	Conditional discrimination training	8
	Equivalence testing	18
	Transfer testing	1
Brian	Assessment of reinforcing and nonreinforcing stimuli	30
	Conditional discrimination training	6
	Equivalence testing	9
	Transfer testing	2
Gloria	Assessment of reinforcing and nonreinforcing stimuli	21
	Conditional discrimination training	5
	Equivalence testing	12
	Transfer testing	2
Sadie	Assessment of reinforcing and nonreinforcing stimuli	4
	Conditional discrimination training	2
	Equivalence testing	3
	Transfer testing	1

Table 1. (Continued)

SUBJECT	CONDITION	NUMBER OF SESSIONS
Claudia	Assessment of reinforcing and neutral stimuli/ Conditional discrimination training	1
	Equivalence testing/transfer testing	1
Dorothy	Assessment of reinforcing and neutral stimuli/ conditional discrimination training	1
	Equivalence testing/transfer testing	1

Table 2. Stimuli used in visual discrimination tasks

	Assessment of Reinforcing Stimuli		Assessment of Target Stimulus		Transfer Test		
Subject	S+	S-	S+	S-		S+	S-
Damien	hug bid	bug did					*
Gloria	M	W	b	d	(1st)	d	b
	♣	♠			(2nd)	d	b
Brian	3	8	b	d	(1st)	d	b
	on	no			(2nd)		
Claudia	 	 					*
Dorothy	 	 					*
Sadie	 	 					*

* The discrimination task used in the transfer test was identical to that used to assess the target stimulus for this subject.

stimulus, which had also been individually identified for each subject during phase 1. The procedure by which these reinforcing and nonreinforcing stimuli were identified is described in the following section. The reinforcing stimuli for the four children included raisins, a Viewmaster, and a toy piano, and the nonreinforcing stimuli included a bottle cap, an index card, and a professional journal. Additional stimuli needed for conditional discrimination training were randomly selected for each subject from a pool of items collected by the experimenter.

It was initially intended that similar reinforcing stimuli would be identified for each of the two adult subjects. However, data collected from pilot subjects suggested that stimuli such as those identified for the child subjects were not effective reinforcers for college students. Instead, information about the accuracy of responding appeared to be a more effective consequence with these subjects. Thus, for the two adult subjects, reinforcing stimuli were words such as "correct" or "right" printed on three by five index cards. Nonreinforcing stimuli consisted of phonetically regular nonsense words (e.g., quib) with which the subjects were unfamiliar. These words were selected from the Word Attack subtest of the Woodcock Reading Mastery Tests (Woodcock, 1973).

When not in use, all stimulus objects were placed on a small table next to the experimenter and out of view of the subject. The six stimuli used during conditional discrimination training for each subject are presented in Table 3.

Procedure

There were four phases to the experiment. In the first phase, two reinforcing stimuli and a nonreinforcing stimulus were identified for each subject. In the second phase, subjects were taught a series of conditional discriminations using the nonreinforcing stimulus and established reinforcers as well as three randomly selected items. In the third phase, testing was conducted to determine whether equivalence classes had formed. In the fourth phase, testing was conducted to determine if the nonreinforcing stimulus that had participated in the equivalence class had acquired a reinforcing function.

Phase 1: Assessment of reinforcing and nonreinforcing stimuli. The reinforcing value of the stimuli was assessed by presenting the stimulus in question immediately following correct responding on a two-choice visual discrimination task. During this phase, subjects were presented with a series of discrimination tasks. Stimuli were presented successively for all subjects except Gloria, because she demonstrated perseverative responding on successive

Table 3. Stimuli used in conditional discrimination training

Damien	A = viewmaster (reinforcer) B = journal (target stimulus) C = raisin (reinforcer) D = small cardboard box E = spoon F = tape roll
Gloria	A = toy piano (reinforcer) B = wood block (target stimulus) C = Smarties candy (reinforcer) D = index card E = thimble F = empty thread spool
Brian	A = Smarties candy (reinforcer) B = index card (target stimulus) C = Cheese Nip cracker (reinforcer) D = paper clip E = empty tic tac box F = rubber eraser
Claudia	A = RIGHT (reinforcer) B = QUIB (target stimulus) C = GOOD (reinforcer) D = NO E = WRONG F = LAIP
Dorothy	A = CORRECT (reinforcer) B = KNAP (target stimulus) C = RIGHT (reinforcer) D = INCORRECT E = WRONG F = HODE
Sadie	A = Silly Putty (reinforcer) B = bottle cap (target stimulus) C = toy piano (reinforcer) D = ruler E = glass paperweight F = yarn

presentations of stimuli (i.e., responding "yes" on all trials). As a result, simultaneous stimulus presentation was used with her.

In the successive presentation arrangement, each trial was initiated by the experimenter holding one of two visual stimuli in front of the subject and asking "Is this ____?" (e.g., "b"). Stimulus presentation was varied in a predetermined random order, with the restriction that neither stimulus was presented more than three times consecutively.

In the simultaneous presentation procedure, a trial was initiated by the experimenter placing a pair of stimuli on the table in front of the subject and instructing the subject to "Point to ____" (e.g., "on"). The position (left/right) of the cards on the table was varied in a predetermined random order, with the restriction that neither position was correct more than three times consecutively.

The consequences were the same regardless of whether stimuli were presented sequentially or simultaneously. If the subject made a response that was designated "correct," the stimulus being assessed was presented briefly (10 seconds). If a subject responded incorrectly, an alternative stimulus that had been chosen randomly from a collection of items (such as a spool) was presented briefly. Thus, all responding resulted in the presentation of some stimulus. The experimenter did not look at the

subject or make any vocalizations when consequences were presented, in order to avoid providing any information about the accuracy of a response. If a subject failed to respond within 5 seconds, the stimulus (or stimuli) was (were) removed to end the trial. The next trial began with the presentation of a new stimulus display.

A stimulus was defined as a reinforcer if the subject made nine out of ten correct responses on two consecutive blocks of ten trials. A stimulus was defined as a nonreinforcing stimulus if the average number of correct responses across blocks of trials was five or less. The nonreinforcing stimulus was used to measure the transfer of reinforcing function during Phase 3 and will hereafter be referred to as the target stimulus.

Phase 2: Conditional discrimination training. During this phase, subjects were individually taught a series of conditional discriminations: If stimulus A, then response B; If stimulus D, then response E; If stimulus A, then response C; If stimulus D, then response F (see Figure 2). The tasks were manually presented in a matching-to-sample format. Before each trial, the experimenter placed the two comparison stimuli on the table behind a screen, preventing the subjects from viewing the comparison stimuli. Each trial was initiated by the experimenter showing the subject the sample stimulus by holding it in front of the screen. The subject was then instructed to touch the comparison stimulus that corresponded to the sample, and the screen was

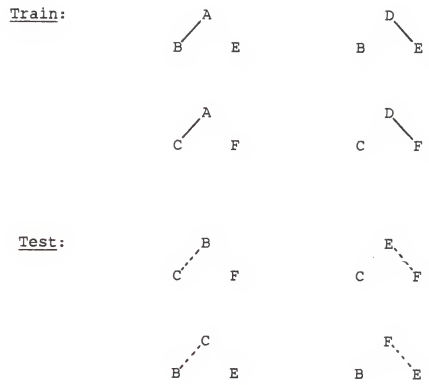

Figure 2. Conditional discrimination training and testing relations.

removed, revealing the comparison stimuli. For example, if a Viewmaster had been presented as the sample (A), touching the raisin (B) would have resulted in the experimenter saying "correct" and touching the spoon (E) would have resulted in the experimenter saying "incorrect." However, if the box (D) had been presented as the sample, touching the spoon (E) would have been "correct," and touching the raisin (B) would have been "incorrect."

On all training trials, the sample was presented with two comparisons. Thus there were four types trials during conditional discrimination training: trials with A as the sample, B and E as comparisons (B is "correct"); trials with D as the sample, B and E as comparisons (E is "correct"); trials with A as the sample, C and F as comparisons (C is "correct"); and trials with D as the sample, C and F as comparisons (F is "correct"). (Refer to Figure 2.) The comparison stimuli were counterbalanced across trials for left-right position to ensure that responding was controlled by the stimulus, rather than by position. Stimuli A and C had been previously identified as reinforcers, and stimulus B was the target stimulus.

The training sequence was the same for each subject and proceeded as follows. First, A was presented as the sample with B and E as the comparisons. When subjects made a correct response (touching the B stimulus) the experimenter said "correct." Incorrect responses (touching E) were followed by the experimenter saying "no." The screen was

then replaced to end the trial. The next trial presented a new stimulus display. The mastery criterion for all tasks during conditional discrimination training was nine out of ten consecutive correct responses on two consecutive blocks of ten trials.

When performance on the A-B task met criterion, those discriminations were discontinued, and training was begun on D-E. For this task, D served as the sample and B and E served as the comparison stimuli. Selecting E in the presence of the D stimulus resulted in the experimenter saying "correct," and incorrect responses were followed by "no." When criterion was met on this conditional discrimination task, the two tasks, A-B and D-E, were mixed. The A and D stimuli continued to serve as the sample stimuli, with B and E as comparisons, but the tasks were presented in a random order.

Following mastery of the mixed task, training started on A-C. Training was identical to that described above, with the exception that the sample was A, and the comparison stimuli were now C and F. In the presence of A, touching C was correct. Once this task was mastered, training on A-C was discontinued and D-F was taught. Following criterion performance on D-F, A-C and D-F were mixed and presented to the subject. Finally, following criterion performance on the mixed A-C and D-F task, the stimuli from all four tasks were mixed and presented randomly.

During initial training, information about the accuracy of responses ("correct" or "incorrect") followed each trial. Following criterion performance on the final mixed task (A-B, D-E, A-C, and D-F), 8 unreinforced trials were intermixed with 24 reinforced trials in a 32 trial training session (cf., Spradlin & Saunders, 1984). Training in this continued until the subject performed at mastery criterion. Reinforcement density at this point was equivalent to that arranged during the probe sessions to follow.

Phase 3: Equivalence testing. The probe trial stimuli were identical to those used during the conditional discrimination training portion of the study described above. However, during this portion of the study, the stimuli that served as samples were stimuli that had previously been comparisons during the conditional discrimination training (see Figure 2).

A correct response during this test was defined as one that would be expected if an equivalence class had formed. As explained by Sidman and Tailby (1982), after teaching two relationships that have a common sample, A-B and A-C, symmetry and transitivity can be simultaneously assessed by testing the relations B-C and C-B. If the relationship is symmetrical, so that both A-B and B-A hold true, then B-A and A-C will yield B-C via transitivity. Likewise, if the A-C relationship is symmetrical, then C-A and A-B will yield C-B via transitivity.

Thus, in this experiment there were four types of probe trials: trials with B as the sample, and C and F as comparisons (C is "correct"); trials with E as the sample, and C and F as comparisons (F is "correct"); trials with C as the sample, and E and B as comparisons (B is "correct"); and trials with F as the sample, and E and B as comparisons (E is "correct"). Probe trials were intermixed with training trials to ensure maintenance of performance. No feedback about performance was provided on probe trials. The measure of interest during the equivalence test phase was the number of "correct" responses. Testing continued until subjects reached a criterion of 9 out of 10 correct responses on two consecutive blocks of ten probe trials.

Phase 4: Testing for transfer of reinforcing function. Finally, the degree to which the transfer of reinforcing function was obtained was assessed by determining the degree to which the target stimulus controlled responding on a visual discrimination task. The same visual discrimination tasks used in the pretest were used in the transfer test. There were two exceptions to this; with Gloria and Brian the discrimination was reversed. That is, whereas "b" had served as the S+ in the pretest, it served as the S- in the transfer test. The reason for this reversal is explained in the Discussion section.

During the transfer test, correct responses were followed by the presentation of the target stimulus (stimulus B from the equivalence class). Incorrect responses resulted in the presentation of the same alternative stimulus presented following "incorrect" responses in Phase 1. The target stimulus and alternative stimulus (respectively) for each subject were as follows: Damien (journal, coaster); Sadie (bottle cap, wooden ruler); Dorothy (Knap, Hode); Claudia (Quib, Laip); Gloria (wood, sponge); Brian (index card, paper clip). If transfer of reinforcing function occurred, "correct" responses should be above pretest levels.

Recording

Responses were manually recorded on a trial-by-trial basis by the experimenter using pre-coded data sheets. Responses were scored as correct, incorrect, or no response. A correct response on the visual discrimination tasks was defined as saying "yes" when asked "Is this ____?" in the presence of the stimulus designated as correct or "no" in the presence of the stimulus designated as incorrect. An incorrect response on visual discrimination tasks was the reverse (i.e., saying "no" when shown the designated correct stimulus or "yes" when shown the

designated incorrect stimulus). Any trial in which a subject failed to respond within five seconds was scored as no response.

During conditional discrimination training and equivalence testing, a correct response was defined as touching the correct comparison stimulus. Incorrect responses during this phase were defined as touching the incorrect comparison or touching both comparison stimuli. Trials were scored as no response if the subject failed to touch either of the comparison stimuli within 5 seconds.

RESULTS

Assessment of Reinforcing Stimuli

Data for individual subjects are presented in Figures 3 through 8. Each graph represents the data for one subject. The data are graphed as the number of correct responses and no responses in blocks of ten trials. Mastery criterion was 9 out of 10 correct responses on two consecutive blocks of ten trials.

The data for Damien are presented in Figure 3. The data presented in the top graph were obtained on a discrimination task in which the S+ was "hug" and the S- was "bug." The consequence for correct responding was 10 seconds access to a Viewmaster toy; the consequence for incorrect responding was 10 seconds access to an empty thread spool. Correct responding ranged from 5 to 10 per ten trial block. The average number of correct responses across blocks of trials was 8.6. The data presented in the bottom graph were obtained on a visual discrimination task in which the S+ was "did," and the S- was "bid." The consequence for correct responding was a raisin; the consequence for incorrect responding was 10 seconds access

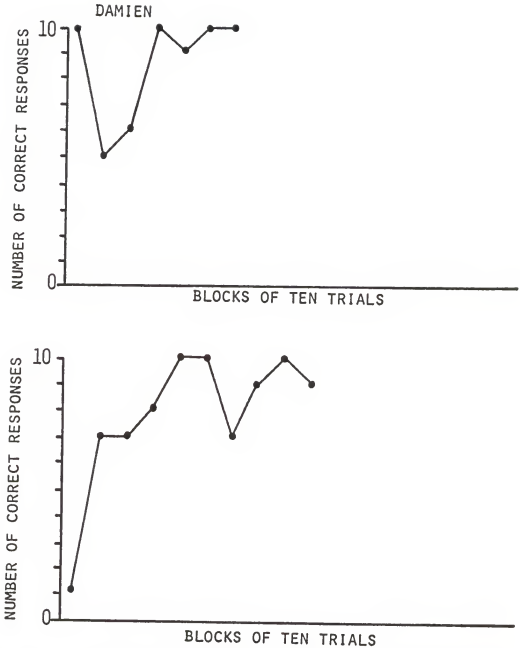

Figure 3. Individual reinforcer assessment data for Damien. The data are graphed as the number of correct and incorrect responses in blocks of ten trials. The upper graph represents Damien's performance on a task in which the S+ was "hug"; the S- was "bug". The consequence for correct responding was 10 seconds access to a Viewmaster; the consequence for incorrect responding was 10 seconds access to an empty thread spool. The lower graph represents Damien's performance on a task in which the S+ was "bid"; the S- was "bid". The consequence for correct responding was a raisin; the consequence for incorrect responding was 10 seconds access to a spoon.

The data for Gloria are presented in Figure 4. The top graph represents Gloria's performance on a visual discrimination task in which the S+ was "M," and the S- was "W". Correct responding resulted in 10 seconds access to a toy piano; incorrect responding resulted in 10 seconds access to a blackboard eraser. Number of correct responses averaged 6.6 across blocks of ten trials (range 3 to 10). The bottom graph represents Gloria's performance on a discrimination task in which the S+ was a club (from a deck of cards); the S- was a spade. Correct responses were followed by a Smartees candy; incorrect responses were followed by 10 seconds access to an empty tape roll. The average number of correct responses across blocks of trials was 6 (range 2 to 10).

The reinforcer assessment data for Brian are presented in Figure 5. The data from task one are presented in the graph on the top half of the page. On this task, the S+ was "3"; the S- was "8." Correct responses were followed by a Cheese Nip cracker; incorrect responses were followed by 10 seconds access to a plastic coaster. The number of correct responses per ten trial block ranged from 2 to 10. The average number of correct responses across blocks of trials was 7.9. The data from task 2 are presented in the graph on the bottom. On this task the S+ was "on"; the S- was "no." The consequence for correct responding was a Smartees candy; the consequence for incorrect responding was 10 seconds

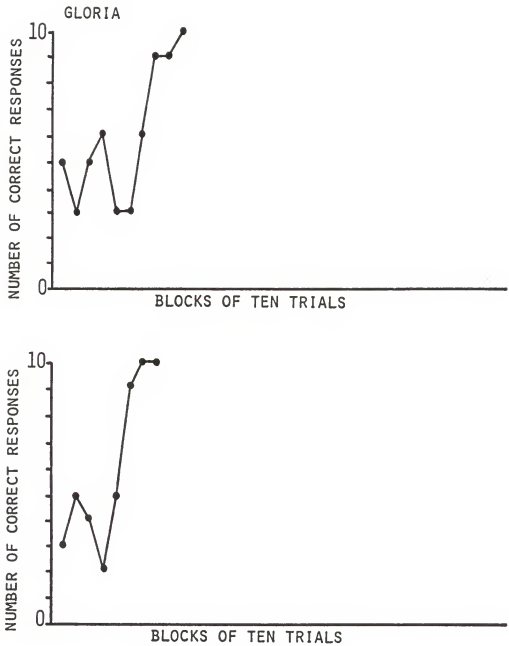

Figure 4. Individual reinforcer assessment data for Gloria. The data are graphed as the number of correct and incorrect responses in blocks of ten trials. The data for task 1 are presented in the upper graph. The S+ was M; the S- was W. The consequence for correct responding was 10 seconds access to a toy piano; the consequence for incorrect responding was 10 seconds access to a blackboard eraser. The data for task 2 are presented in the lower graph. In this task the S+ was a drawing of a club; the S- was a drawing of a spade. The consequence for correct responding was a Smartees candy; the consequence for incorrect responding was 10 seconds access to an empty tape roll.

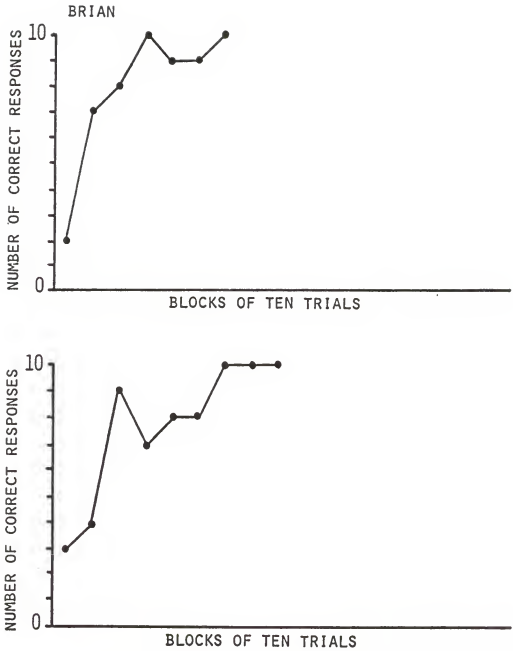

Figure 5. Individual reinforcer assessment for Brian. The data for task 1 are presented in the upper graph. In this task the S+ was the number 3; the S- was the number 8. The consequence for correct responding was a Cheese Nip cracker; the consequence for incorrect responding was 10 seconds access to a paper clip. The data for task 2 are presented in the lower graph. In this task the S+ was the word "on"; the S- was the word "no." The consequence for correct responding was a Smartees candy; the consequence for incorrect responding was 10 seconds access to a small piece of foam rubber.

access to a small piece of foam rubber. The number of correct responses ranged from three to 10 per ten trial block and averaged 7.7 across blocks.

The reinforcer assessment data for Sadie are presented in Figure 6. The stimuli used in both visual discrimination tasks were Chinese characters (see Table 2 for the specific stimuli for this subject). The data presented in the top graph represent the subject's performance on task one. The consequence for correct responding on this task was 10 seconds access to Silly Putty; the consequence for incorrect responding was 10 seconds access to a small glass paperweight. Correct responding on this task ranged from 5 to 10 with an average of 8 correct responses across blocks of trials. The data presented in the bottom graph represent the subject's performance on task two. On this task correct responses were followed by 10 seconds access to a toy piano; incorrect responses were followed by 10 seconds access to a plastic ball point pen cap. The average number of correct responses across blocks of ten trials was 7.3 (range four to nine).

The data for Dorothy are presented in Figure 7. The stimuli used in both visual discrimination tasks were Chinese characters (see Table 2). On task one (top graph), correct responses were followed by a 10 second presentation of the printed word "correct"; incorrect responses were followed by a 10 second presentation of the printed word "incorrect." The number of correct responses across three

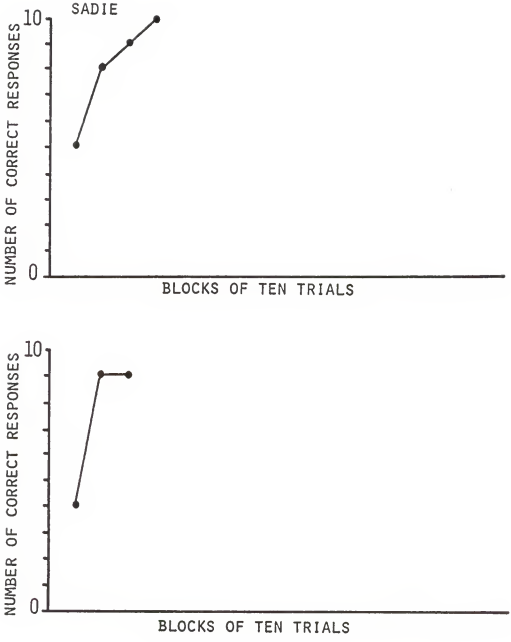

Figure 6. Individual reinforcer assessment data for Sadie. The stimuli used in the discrimination tasks were Chinese characters. These stimuli are presented in the first column of Table 2. The stimuli in the top row correspond to the top graph; the stimuli in the bottom row correspond to the bottom graph. The data are graphed as the number of correct responses in blocks of ten trials. On task one, the consequence for correct responding was 10 seconds access to Silly Putty; the consequence for incorrect responding was 10 seconds access to a glass paperweight. In task 2, the consequence for correct responding was 10 seconds access to a small toy piano; the consequence for incorrect responding was ten seconds access to a plastic ballpoint pen cap.

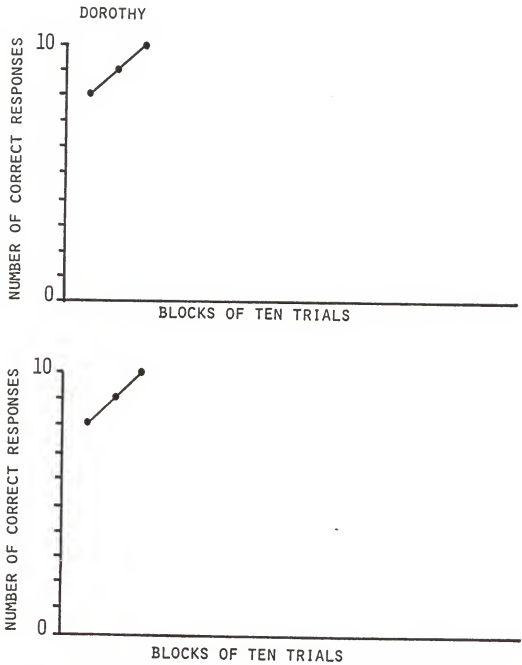

Figure 7. Individual reinforcer assessment data for Dorothy. Chinese characters served as the S+ and S- stimuli for both discrimination tasks. The particular characters used for each task are presented in the first column of Table 2. For task 1, the consequence for correct responding was presentation the word "correct" printed on a 3" x 5" white index card; the consequence for incorrect responding was the word "incorrect" presented in the same manner. For task 2, the consequence for correct responding was the presentation of the printed word "right"; the consequence for incorrect responding was the printed word "wrong."

blocks of ten trials was 8, 9, and 10, respectively. On task two (bottom graph), the consequence for correct responding was a 10 second presentation of the printed word "right"; the consequence for incorrect responding was a 10 second presentation of the printed word "wrong." The number of correct responses across three blocks of ten trials was 8, 9, and 10, respectively.

The individual reinforcer assessment data for Claudia are presented in Figure 8. The visual stimuli used in both discrimination tasks were Chinese characters (see Table 2). On task one (top graph), correct responses resulted in a 10 second presentation of the printed word "good"; incorrect responses resulted in a 10 second presentation of the printed word "no." Correct responses increased from eight in the first block of trials to 10 in the two subsequent blocks. On task two (bottom graph), correct responses were followed by a 10 second presentation of the printed word "fine"; incorrect responses were followed by a 10 second presentation of the printed word "wrong." The number of correct responses per ten trial block ranged from 6 to 10. The average number of correct responses across blocks was 8.5.

The arranged consequences for responding were effective in generating discriminative performances on two different visual discrimination tasks for each of the six subjects. The observation that correct responses increased to mastery criterion (9 out of 10 correct on two consecutive blocks of

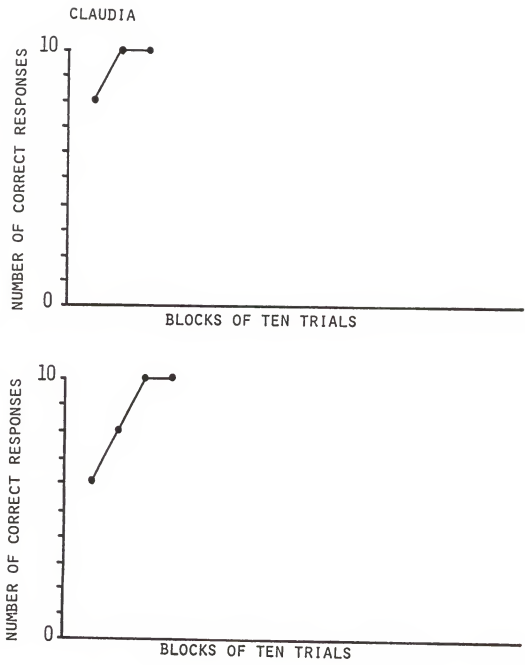

Figure 8. Individual reinforcer assessment data for Claudia. All stimuli were Chinese characters. These characters are presented in the first column of Table 2. For task 1, the consequence for correct responding was the printed word "Good"; the consequence for incorrect responding was the printed word "No." For task 2, the consequence for correct responding was the printed word "Fine"; the consequence for incorrect responding was the printed word "Wrong."

10 trials) indicates that in each case the stimulus that followed correct responses functioned as a reinforcer relative to the stimulus that followed incorrect responses.

Conditional Discrimination Training

The individual data for each subject are presented in Figures 9 and 10. The data for one subject are shown in individual graphs expressed as the number of correct responses over blocks of ten trials. The tasks (A-B, D-C, etc.) are indicated above each panel.

All subjects quickly mastered the conditional discriminations. Four subjects (Claudia, Dorothy, Sadie, and Gloria) completed the seven stages of the conditional discrimination training (A-B, D-C, mix, A-E, D-F, mix, and the final mix) in 140 trials, which was the minimum possible trials to criterion. Brian required 160 trials to master the seven stages of this phase; Damien required 200 trials. The mean number of trials required to mastery criterion of all stages of the conditional discrimination training phase was 155 trials.

Equivalence Test

Figures 9 and 10 also show that all subjects performed in a manner consistent with the formation of equivalence classes. That is, each subject's performance on probe

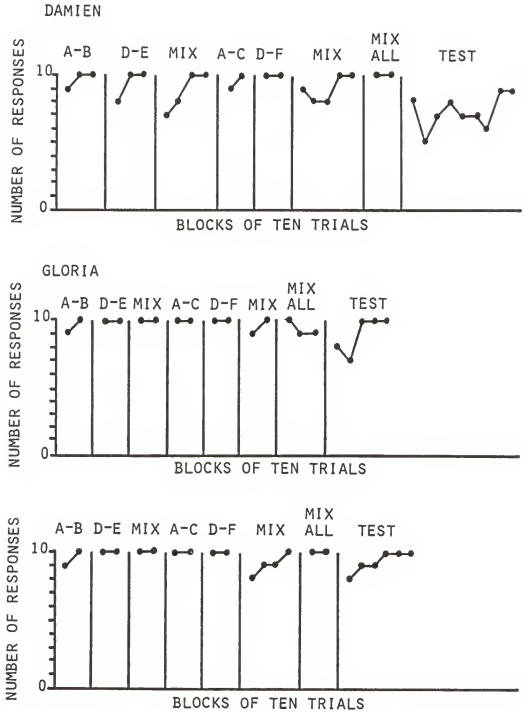

Figure 9. Individual conditional discrimination training and equivalence testing data for Damien, Gloria, and Brian. The data are graphed as the number of correct responses in blocks of ten trials. The training and testing phases are indicated within each graph. The test data are for equivalence probes only; data from baseline trials have been omitted.

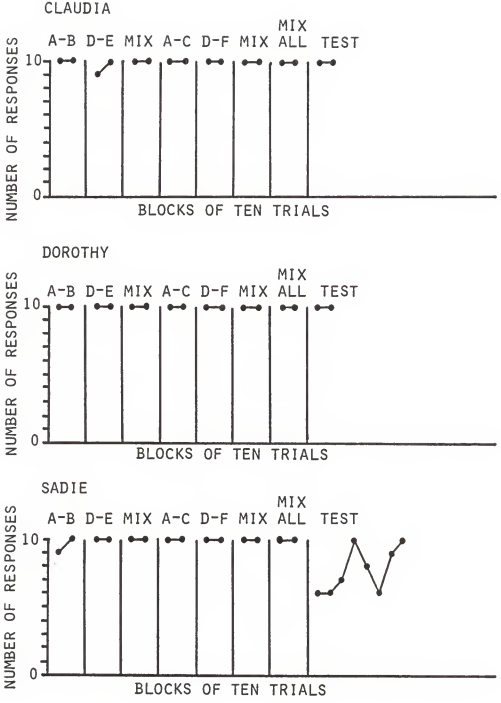

Figure 10. Individual conditional discrimination training and equivalence testing data for Claudia, Dorothy, and Sadie. The data are graphed as the number of correct responses in blocks of ten trials. The training and testing phases are indicated within each graph. The test data are for equivalence probes only; data from baseline trials have been omitted.

trials reached the mastery criterion of 9 out of 10 correct responses on two consecutive blocks of ten probe trials. Both of the adult subjects (Claudia and Dorothy) reached mastery criterion on 20 probe trials, which was the minimum possible. The number of probe trials required to mastery criterion varied for each of the child subjects. Gloria and Brian required 40 and 50 probe trials, respectively. Sadie and Damien required 80 and 90 probe trials, respectively, to meet criterion on the equivalence test. The average number of probe trials across all subjects was 50.

Probe trials were interspersed with baseline trials according to a ratio of one to three. Performance on the baseline trials during equivalence testing remained highly accurate for all subjects. The average number of correct baseline trials for Damien was 9.8 across 460 trials. The average number of correct baseline trials for Brian was 9.6 across 190 trials. The average number of correct baseline trials for Gloria was 9.6 across 220 trials. The average number of correct baseline trials for Sadie was 9.9 across 200 trials. Both of the adult subjects (Claudia and Dorothy) performed at 100 percent accuracy across all baseline trials during equivalence testing. The number of correct and incorrect responses for blocks of ten baseline trials for each subject are presented in the Appendix.

Transfer Test

Four subjects (Damien, Sadie, Dorothy, and Claudia) clearly showed the transfer of reinforcing function. Data for these subjects are presented in Figures 11 through 14. The pretest and transfer test data for Damien are presented in Figure 11 in blocks of ten trials. His pretest correct responding averaged 2.2 (range zero to 7). In contrast, correct responding on the transfer test averaged 8.3 across blocks of trials. Thus, a stimulus that previously failed to maintain correct responding (a professional journal) succeeded in maintaining responding after participation in an equivalence class with the established reinforcers.

Sadie's data show the same effect. Data for this subject are presented in Figure 12. In the pretest, correct responding averaged 5.2 (range 3 to 6). In contrast, on the transfer test, her number of correct responses averaged 8.3 (range 4 to 10).

Similar results were obtained for Dorothy and Claudia, whose data presented in Figures 13 and 14, respectively. For Dorothy, the average number of correct responses across blocks of ten trials was 1.8 (range zero to 6). In contrast, performance on the transfer test ranged from 8 correct to 10 correct, averaging 9.2. Claudia's pretest correct responding averaged 2.3 (range zero to 7). In contrast, this subject demonstrated errorless responding on the transfer test.

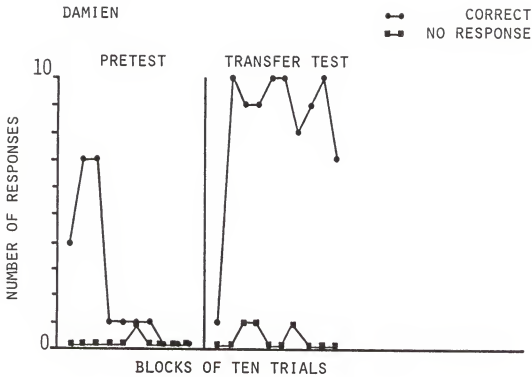

Figure 11. Pretest and transfer test data for Damien. Pretest data are presented in the left panel; transfer test data are presented in the right panel. The data are graphed as the number of correct and no response trials in blocks of ten trials. In both the pretest and the transfer test the S+ and S- were Chinese characters. (These characters are presented in the second column of Table 2.) In both phases the consequence for correct responding was 10 seconds access to a professional journal; the consequence for incorrect responding was 10 seconds access to a plastic coaster.

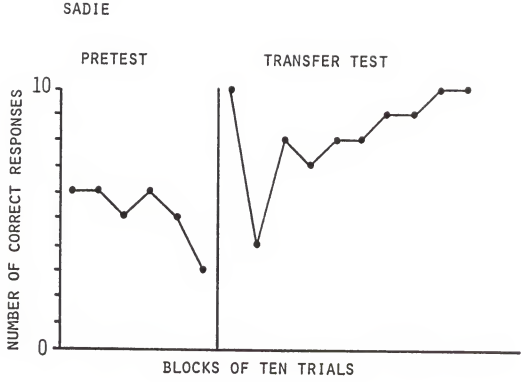

Figure 12. Pretest and transfer test for Sadie. In both the pretest and the transfer test the visual discrimination stimuli were Chinese characters. These stimuli are presented in the second column of Table 1. In both phases, the consequence for correct responding was 10 seconds access to a bottle cap; the consequence for incorrect responding was 10 seconds access to a wooden ruler.

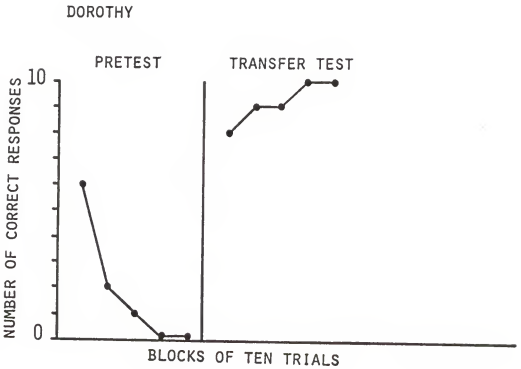

Figure 13. Pretest and transfer test data for Dorothy. In both the pretest and transfer test the S+ and S- were Chinese characters. (See column two in Table 2.) In both phases the consequence for correct responding was 10 seconds presentation of the word KNAP; the consequence for incorrect responding was 10 seconds presentation of the word HODE.

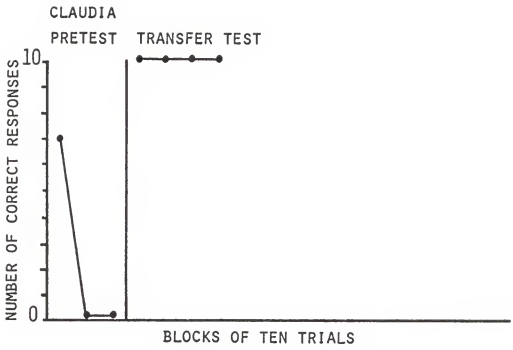

Figure 14. Pretest and transfer test data for Claudia. In both the pretest and the transfer test the stimuli used were Chinese characters. (See column two in Table 2.) In both phases the consequence for correct responding was 10 seconds presentation of the word QUIB; the consequence for incorrect responding was 10 seconds presentation of the word LAIP.

Two subjects did not demonstrate the transfer effect, however. The data for Gloria are presented in Figure 15. Correct responding in the pretest averaged 5.5 (range 4 to 6). As mentioned previously, the discrimination task was reversed on the transfer test for this subject. That is, whereas the subject had originally been asked to "point to b" she was now instructed to "point to d." The consequences for responding were identical to those in the assessment phase: wood block for correct responses, sponge for incorrect responses. Number of correct responses for blocks of ten trials on the transfer test ranged from zero to 9 with an average of 3.5 correct responses across blocks of trials. Following this initial transfer test, equivalence testing was repeated to insure that the conditional relationships were maintained, and the transfer test was then repeated. Correct responses on this second test ranged from 3 to 9 for blocks of ten trials, with a mean of 6.1 correct responses across all trials.

The data for Brian are presented in Figure 16. In general, no difference was observed in this subject's performance across conditions. Brian averaged 5 correct responses across blocks of trials on the pretest. On the transfer test, the average number of correct responses was 5.7. Following this initial transfer test, a series of 32 trials (24 conditional discrimination trials interspersed with 8 probe trials) was interjected to insure that equivalence classes were intact. A second transfer test

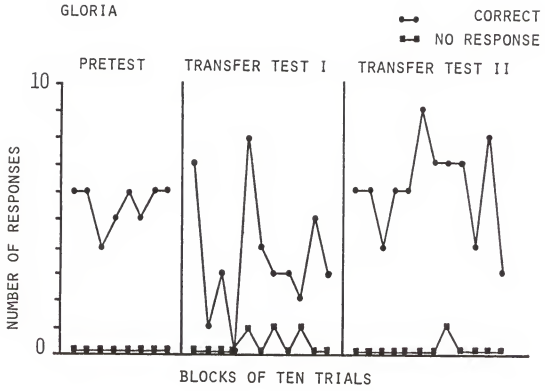

Figure 15. Pretest and transfer test data for Gloria. The discrimination task in the pretest was b-d. In both transfer test 1 and transfer test 2, the discrimination task was d-b. In all phases, the consequence for correct responding was 10 seconds access to a block of wood; the consequence for incorrect responding was 10 seconds access to a dry sponge.

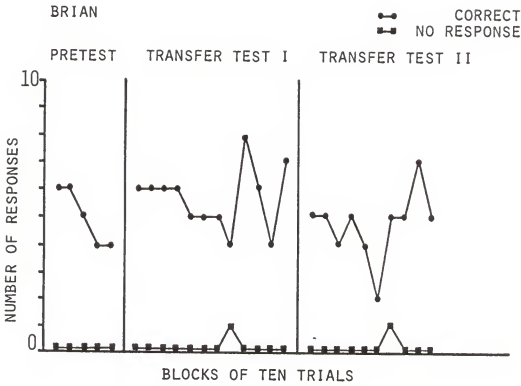

Figure 16. Pretest and transfer test data for Brian. In the pretest the discrimination task was b-d. On transfer test 1 the discrimination task was d-b. On transfer test 2 the stimuli used in the discrimination task were Chinese characters. (These characters are presented in column three of Table 1.) In the pretest as well as both transfer tests, the consequence for correct responding was 10 seconds access to an orange 3"x 5" index card; the consequence for incorrect responding was 10 seconds access to a plastic coaster.

using a novel (i.e., unfamiliar) discrimination task was then introduced. On this task, the average number of correct responses was 4.7.

DISCUSSION

All subjects mastered a series of conditional discriminations, resulting in the formation of a three-member equivalence class. Two members of the class had been identified as reinforcing stimuli prior to class formation, and one member had been identified as a nonreinforcing stimulus. Following equivalence class formation, testing was conducted to determine if the previously nonreinforcing stimulus had acquired the reinforcing function. Discriminative responses that were consequated by presentation of the target stimulus (i.e., correct responses) increased well above pretest levels for four of the six subjects. The data from these four subjects answered the primary question of this experiment in the affirmative: a response-produced arbitrary stimulus can acquire a reinforcing function by participating in an equivalence class with established reinforcers.

These findings are consistent with the results of the only other study known to have specifically addressed the issue of transfer of reinforcing functions (i.e., Hayes et. al., in press). However, the present study differs from Hayes et al. in at least two important ways. One difference

is the task used to determine whether transfer occurred. Recall that Hayes et al. used a task in which adult subjects sorted nonsense syllables into two bins. Although two of the subjects in Hayes et al. demonstrated a high degree of accuracy in responding on the transfer test, the task used did not rule out the possibility that responding was affected by factors other than the contingent presentation of the target stimulus.

For example, work with pilot subjects in the present study indicated that with adult subjects the response emitted on the first trial was consistently emitted on remaining trials, regardless of the programmed consequences. For example, a subject might have been given a visual discrimination task in which two Chinese characters were presented sequentially. Suppose that on the first trial the experimenter presented Chinese character #1 and asked "Is this ling?" If an adult subject responded "yes" to this question in the presence of Chinese character #1, she consistently answered "yes" on all subsequent presentations of that stimulus, regardless of the programmed consequences. This response strategy would produce either zero percent correct or 100 percent responding, with responding being the same as the response on the first trial, and independent of the programmed consequences. Thus, while two subjects in Hayes et al. demonstrated 100 percent correct responding on the transfer test, these

results cannot unequivocally be attributed to the transfer of reinforcing function. The results may have due to perseveration of responding as described above.

In contrast, the tasks used in the present study were designed to generate differential responding that could clearly be attributed to the effects of differential reinforcement. The use of unfamiliar stimuli whose differences were presumably less obvious to subjects than the difference between the nonsense syllables used by Hayes et al. made it possible to observe the acquisition of differential responding. Thus, the tasks used to measure transfer in this study suggest that differential performance was due to contact with the arranged consequences, and the findings demonstrate clearly that the transfer effect occurred with four subjects.

A second difference between the present study and the research of Hayes et al. concerns the establishment of reinforcing stimuli. In Hayes et al., an equivalence class was formed, after which one member of the class was presumed to be given a reinforcing function through a classical conditioning procedure. That is, one member of the existing equivalence class was paired with the vocal response "good." It was assumed by Hayes et al. that the equivalence class member acquired a reinforcing function as a result of this pairing procedure (although this assumption was not adequately tested) and that the reinforcing function would, in turn, transfer to other members of the class. In

contrast, in the present study the equivalence class was formed only after the functions of the stimuli had been experimentally established. Thus, this study is the first to demonstrate that a stimulus can acquire a reinforcing function when, through training or experience, it becomes functionally equivalent with members of an existing class of reinforcers.

Another important contribution of the present study is that it extends the generality of the transfer effect. Previous studies of the transfer of both discriminative and reinforcing functions via equivalence classes have reported data obtained from adult subjects. This investigation demonstrates the transfer of reinforcing function in equivalence classes with children. Together with the findings of Silverman et al. (1986), these data indicate that the transfer phenomenon is not restricted to individuals with the advanced repertoires of college students. It might be expected that this phenomenon would play an important role in normal development. The point in development at which children demonstrate the effect and the role it plays in the acquisition of other behaviors are unknown and await further experimental investigations.

Measurement of Reinforcement Effectiveness

In the present study, a discrete trials procedure using a choice task was used to measure the relative effectiveness of different consequences. The subject was instructed to emit a response whenever a stimulus was presented. The effectiveness of the target stimulus as reinforcement was assessed against the level of responding in the pretest.

Because the response class being reinforced (e.g., saying "yes" in the presence of S+ and "no" in the presence of S-) is different than the response class prompted by the instruction (e.g., answer a yes/no question about a drawing), this procedure avoids confounding reinforcement and instructions (Redd, Winston, & Morris, 1977). That is, although emitting a response when asked a question by an experimenter may be at least partially under instructional control, the differential responding observed may be assumed initially to be due to differential consequences. Thus, any change in the level of correct responding on the transfer test may then be assumed to be due to a change in the effectiveness of the target stimulus as reinforcement. Correct responding in the test phase for four subjects increased well above correct responding in the pretest phase, suggesting that the reinforcing value of the target stimulus increased.

The above reasoning does not exclude the possibility that test performance was influenced by other unplanned sources of reinforcement. One possible source of social reinforcement could have been subtle cues inadvertently emitted by the experimenter (the Clever Hans effect, Sebeok, 1980). Precautions taken against such unplanned reinforcement included avoiding eye contact with the subject when delivering consequences, making no vocalizations following a subject's response, and making notations on the data sheet (which was hidden from the subjects' view) following all responses. Despite these efforts to minimize experimenter cues, the possibility of subtle difference in reactions cannot be eliminated in this procedure. However, in the Wulfert and Hayes (1987) study of the transfer of discriminative control, transfer was obtained when the subjects interacted only with automated equipment, ruling out the possibility of inadvertent experimenter cues. The present data are consistent with Wulfert and Hayes, as well as with other experiments on transfer of stimulus functions (e.g., Lazar, 1977; Hayes et al., 1987).

Possible Reasons for Poor Performance

The present data demonstrate that a stimulus may acquire a reinforcing function when it is made functionally equivalent with existing reinforcers through matching-to-sample training. Certain features of the

present data indicate that membership in an equivalence class may not be sufficient to ensure that transfer will occur. Two child subjects, Brian and Gloria, performed in a manner consistent with the formation of equivalence classes, yet no differential performance was observed on the transfer test. This is puzzling given that the other two children did demonstrate transfer with no apparent problem.

What factors, other than failure to transfer, might account for the failure to obtain discriminative responding? One possible explanation for failure to demonstrate mastery on the transfer test is that the subjects could not distinguish between the two letters (b and d). However, this explanation was anticipated and evaluated following the pretest. In order to assess the subject's ability to distinguish between the two letters, the same task was repeated over a series of trials in which the consequence for correct responding was a previously identified reinforcer. For both subjects, correct responding quickly reached mastery criterion. Thus, an inability to respond differentially to the letters cannot explain the lack of discriminative performance on the transfer test.

Because these two subjects had mastered the discrimination task used in the pretest, the task was reversed in the transfer test. This sequence creates the possibility that the lack of discriminative responding on

the transfer test resulted from the subjects' previous reinforcement history with respect to these stimuli. When a discrimination is reversed, differential performance is typically eliminated as the original discrimination vanishes, and then reappears when a new discrimination is formed (e.g., Wyckoff, 1969). Thus, it is possible that discriminative performance might have been observed on the transfer test if more trials had been presented, or if a novel discrimination task had been used.

Both of these possibilities were investigated. Each of these subjects was given a review of the conditional discrimination training and probe trials to ensure that the equivalence relations were intact. This was followed by a second transfer test. For Gloria the second test consisted of 120 additional trials of the d-b discrimination task. Although her performance improved somewhat (from an average of 3.7 correct to an average of 6 correct), it did not reach the mastery criterion.

For Brian, the second transfer test consisted of unfamiliar stimuli (Chinese characters). Performance on this second transfer test was also at chance levels. This finding makes it seem unlikely that poor performance on the transfer test was due to overlearning of the previous discrimination or to some particular feature of the stimuli themselves. Even though the possibility remains open that the transfer effect would have been seen had different events or stimuli been used, it must be concluded that the

target stimulus did not function as a reinforcing event for these subjects even following its participation in an equivalence class with existing reinforcers. The reason for this is not known.

The data for these two children raise questions about prerequisites for the occurrence of the transfer of reinforcing function. Extended interactions with these children over the course of the experiment indicated that these two subjects were more like each other than they were like the other subjects. For example, their attention spans were short, and they were socially immature. Their grammatical skills were markedly limited, and their vocabularies were restricted. These commonalities suggest that there may be something about their repertoires or histories that was responsible for the failure to obtain transfer.

It would be reasonable to consider the possibility that deficient language skills may impede transfer or, conversely, that proficient language skills may facilitate transfer. How would language affect performance on this task? One possible way might be through tacting (Skinner, 1957) the relations among the stimuli. For example, one could speculate that a subject tells herself something like this: "If I get it right, I get the Silly Putty; if I get it right, I get the toy piano." It might then be assumed that during conditional discrimination training, private verbalizations such as "The bottle cap goes with the Silly

Putty and the bottle cap goes with the toy piano" were emitted. Following this reasoning, it might then be argued that performance on the transfer test is due to the subject engaging in private verbalizations such as "Now the bottle cap means that I got it right." In other words these assumptions would mean that the transfer was accomplished at least in part through the use of mediating behavior.

Such descriptions of the relations, if they occurred, were not articulated to the experimenter by two young subjects. In the pretest, it was not unusual to hear Damien (age 4) groan when he was given the journal following a correct response. After one trial he even commented "I don't like that book." Yet, when asked why he answered the questions on the transfer test the way he did, Damien simply said "I like the book" [journal]. He was unable to provide an explanation when asked what, if anything, had happened to make him like the "book" more than he had previously. Sadie (age 8) made no comments about the consequences in the pretest or on the transfer test. When asked why she responded the way she did on the transfer test, she said "Because the red thing [bottle cap] means you got it right." When asked how she knew that the bottle cap meant "right," Sadie said that she couldn't explain, that she "just knew it."

To date, no studies have investigated the role of mediating behavior in the transfer of stimulus functions. In fact, in the study of stimulus equivalence itself there

is lack of agreement about the role of mediating behaviors. Lowe (1986) has presented some evidence to suggest that children who failed to form equivalence classes succeeded in doing so once they were taught to describe the relations among stimuli. On the other hand, evidence from Sidman's lab (Sidman, Willson-Morris, & Kirk, 1986) supports the view that mediating responses are unnecessary. Thus, the role of mediating behavior in forming equivalence classes, as well as in the transfer of stimulus functions across members of equivalence classes, remains to be determined.

The relation between mediating behaviors and transfer of stimulus functions might be clarified through the use of a training procedure similar to that used by Lowe (1986). Subjects who failed to demonstrate transfer might be identified and provided with instruction regarding the relations between the stimuli. Testing for transfer following mastery of descriptive behavior would determine whether provision of this descriptive repertoire facilitates transfer.

Another research tactic would be to investigate the transfer phenomenon under conditions in which the possibility of language based mediation would be eliminated. One way to approach this would be to conduct research using preverbal children as subjects. However, attempts to establish equivalence classes with nonverbal subjects, either human (Devany et al., 1986) or infrahuman (Sidman et al., 1982) have been unsuccessful.

Implications of This Research

Stimuli that acquire their reinforcing function through experience are known as conditioned reinforcers (Skinner, 1953). This experience is generally presumed to depend on direct pairing with an existing reinforcer (e.g., Skinner, 1953; Morse & Kelleher, 1977). The present data suggest that there may be another way in which stimuli can come to function as reinforcers, by obtaining membership in an equivalence class of existing reinforcers. This finding may prove important to our understanding of how an array of environmental events that seem unlikely to have been directly paired with primary or secondary reinforcers can acquire reinforcing functions. Suppose, for example, that a person learns that the Spanish word for "good" is "bueno" and that the French word for "bueno" is "bon." If "good" functions as a conditioned reinforcer, it seems likely that "bon" will now also function as a reinforcer, without any training or pairing of "bon" with other events (Hayes et al., in press).

Given that there has been relatively little basic research on the acquisition of conditioned reinforcers in humans, their role in normal human development is not well understood. It is clear that there is a population of individuals who have considerable difficulty acquiring conditioned reinforcers and that these individuals fail to develop normally (e.g., Ferster, 1961; Bijou & Baer, 1967).

Because of the apparent importance of acquired reinforcers in human behavior, it seems imperative to pursue further study of the processes involved in their acquisition. Improved understanding of how normally developing individuals acquire conditioned reinforcers may eventually lead to the development of effective training methods for establishing conditioned reinforcers for individuals who are motivated by only a limited array of events.

Another aspect of the importance of this mechanism for establishing conditioned reinforcers is based on the emerging finding that the stimulus equivalence phenomenon may be critical to our understanding of verbal behavior (Devany et al., 1986; Sidman, 1986). Verbal behavior can exert powerful punishing, reinforcing, and discriminative functions that may not have been generated by contact with naturally occurring contingencies. Although the manner in which this control over behavior is acquired is not now well understood, the study of equivalence classes may prove important to our understanding about this relationship. Continued research on the transfer of stimulus functions via equivalence classes may help us to understand the complexities of human behavior.

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APPENDIX

Number of correct and incorrect responses in blocks of ten baseline trials during equivalence testing for each subject.

SUBJECT	BLOCK	NUMBER CORRECT	NUMBER INCORRECT
Damien	1	10	0
	2	10	0
	3	10	0
	4	9	1
	5	9	1
	6	9	1
	7	10	0
	8	10	0
	9	9	1
	10	9	1
	11	10	0
	12	10	0
	13	10	0
	14	10	0
	15	9	1
	16	10	0
	17	10	0
	18	9	1
	19	10	0
	20	10	0
	21	10	0
	22	10	0
	23	10	0
	24	10	0
	25	10	0
	26	10	0
	27	10	0
	28	10	0
	29	10	0
	30	10	0
	31	10	0
	32	10	0
	33	10	0
	34	10	0
	35	10	0
	36	10	0
	37	9	1
	38	10	0
	39	10	0
	40	10	0
	41	10	0
	42	10	0
	43	10	0
	44	10	0
	45	10	0
	46	10	0

SUBJECT	BLOCK	NUMBER CORRECT	NUMBER INCORRECT
Gloria	1	9	1
	2	9	1
	3	10	0
	4	9	1
	5	9	1
	6	8	2
	7	10	0
	8	9	1
	9	9	1
	10	10	0
	11	10	0
	12	10	0
	13	10	0
	14	10	0
	15	10	0
	16	10	0
	17	10	0
	18	10	0
	19	9	1
	20	10	0
	21	10	0
	22	10	0
Brian	1	10	0
	2	10	0
	3	10	0
	4	10	0
	5	8	2
	6	10	0
	7	8	2
	8	10	0
	9	9	1
	10	10	0
	11	10	0
	12	10	0
	13	10	0
	14	10	0
	15	10	0
	16	9	1
	17	9	1
	18	10	0
	19	9	1

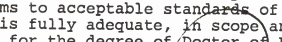
SUBJECT	BLOCK	NUMBER CORRECT	NUMBER INCORRECT
Sadie	1	10	0
	2	10	0
	3	9	1
	4	10	0
	5	10	0
	6	10	0
	7	10	0
	8	10	0
	9	10	0
	10	10	0
	11	10	0
	12	10	0
	13	10	0
	14	10	0
	15	10	0
	16	10	0
	17	10	0
	18	10	0
	19	10	0
	20	10	0
	21	10	0
Claudia	1	10	0
	2	10	0
	3	10	0
	4	10	0
Dorothy	1	10	0
	2	10	0
	3	10	0
	4	10	0

BIOGRAPHICAL SKETCH

Cathy L. Watkins was born in Turlock, California, on May 9, 1953. Following graduation from Turlock High School on June 11, 1971, Ms. Watkins moved to Hawaii. In 1977 she returned to Turlock and, in February of that year, enrolled at California State University, Stanislaus. Her B.A. in psychology was awarded Summa Cum Laude in December, 1981, and she immediately began work on her master's degree. She completed the requirements for the M.A. in psychology and graduated, with distinction, in June, 1983. During the time she attended California State University, Stanislaus, Ms. Watkins was employed as the program coordinator at the Center for Direct Instruction and as a behavior analyst for Valley Mountain Regional Center.

Ms. Watkins began her doctoral studies in psychology at the University of Florida in August, 1983. During the time that she lived in Gainesville, Ms. Watkins was employed as a psychologist at Sunland Center, and as a behavior analyst at the Children's Mental Health Unit at Shand's Teaching Hospital. Following her admission to candidacy, Ms. Watkins moved to Auburn, Alabama, where she is currently an instructor in the Department of Educational Foundations, Leadership, and Technology at Auburn Univeristy.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Henry S. Pennypacker, Chairman
Professor of Psychology

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Edward F. Malagodi, Cochairman
Professor of Psychology

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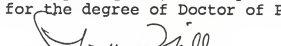

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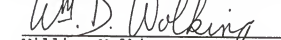

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This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1987

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Dean, Graduate School